THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Jan 2024 Vol.4(1), 361--364
Popular Article

An overview of SNP Chips: Decoding the Blueprint for Genomic Selection in Cattle

Ayushi Singh[1*], Rohit Barwar[1], Ashok Chaudhary[1], Gaurav Patel[2]
[1]Division of Animal Genetics, ICAR-IVRI, Izatnagar, Bareilly (UP)
[2]Divison of Animal Genetics and Breeding, ICAR-NDRI, Karnal (Haryana)
https://doi.org/10.5281/zenodo.10564707

Abstract

SNP chip is a successor of previously explored marker exploring technologies such as microsatellite, Restricted Fragment Length Polymorphism (RFLP) marker. SNP chip explores genome wide variants for economic traits present in cattle which increases its utility for breeding purposes. The development of SNP chip started with BovineSNP50 BeadChip which was developed in 2007.Thereafter, a range of high, medium and low-density SNP chips were developed for better exploration of markers of different traits. Recently, IndiGau chip has been developed to cover the genetic variants present across different Indigenous breeds in India. It has more markers as compared Illumina 777k BOvineHD chip. SNP chips has advantages of increasing genetic progress at faster pace as compared to previously used marker assisted approach. The applications and practicality of SNP chips have grown over years and will continue to increase for cattle breeding purposes in future.

Introduction

In the early 2000s, earlier technologies have already provided a boost in marker assisted selection through different molecular markers i.e. microsatellite markers, RFLP (Restricted Fragment Length Polymorphism) markers, RAPD markers (Random Amplified Polymorphic DNA). However, there was still little progress was made in genetic improvement of cattle population at farm level. Even, the stagnation was felt in further genetic progress for economically important traits such as milk production, fat percentage, lactation length and so on. To address the challenges, there was a need to shift from single marker selection to genome wide marker selection. The issue was catered with the development of SNP chip in 2006 in USA. SNP chips, or single nucleotide polymorphism arrays, are basically a type of DNA microarray used to detect variations covering genome wide variations. With the initial success of introduction SNP chip, now chips have become standard in cattle breeding, contributing to

accelerated genetic progress and informed breeding decisions.

History of SNP Chip

Identification of Single nucleotide polymorphism began way back in 1990s. It was followed by developed of first Bovine SNP chip "Illumina BovineSNP50 bead chip" in December 2007. It has about a set of 54,0001 SNPs genotyped in Holstein cattle in USA. Since then, several commercial whole-genome SNP chips have been developed for cattle genotyping, produced by Illumina and Affymetrix sequencing platforms.

Major SNP chip for cattle developed worldwide

1. **BovineSNP50 BeadChip** – This was one of the first commercially available SNP chips for cattle. It provided a moderate density of markers for genomic studies and genomic selection.
2. **BovineHD BeadChip –** It has about 777,962 SNPs markers and was released in 2012. This chip offered higher marker density, providing more detailed genomic information for accurate genomic evaluations and selection.
3. **Illumina BovineLD BeadChip*:*** It is a low-density chip released in 2017 and number of SNPs are variable in nature. This chip allows for customizable marker selection, catering to specific research or breeding needs. It is particularly useful when focusing on a subset of the genome. Other SNP chips include Affymetrix Axiom Genome-Wide BOS 1 Array, GeneSeek Genomic Profiler (GGP) Bovine Chip, EuroG10K Axiom Array which are catering the needs of various cattle breeding objectives.

SNP chip developed for Indigenous Cattle in India

1. **INDUS Chip:** It was developed by National Dairy Development Board (NDDB), Anand (Gujrat) in 2015. It is a medium density customized chip developed with indigenous breed and their crossbred animals.
2. **INDUS Chip2:** It is an updated version of INDUS chip released by NDDB.
3. **IndiGau Chip:** IndiGau chip is purely indigenous and the largest cattle chip of the world. It was released by National Institute of Animal Biotechnology (NIAB), Hyderabad. It has 11,496 markers (SNPs) more than that placed on 777K Illumina chip of US & UK breeds. IndiGau Chip has been prepared from six major breeds of cattle across India including Sahiwal, Tharparkar, Kankrej, Gir, Kangyam and Ongole.

Advantages of use of SNP chip in animal breeding

The use of Single Nucleotide Polymorphism (SNP) chips in animal breeding offers numerous advantages, revolutionizing the field of genetics and breeding programs. Here are some key advantages of utilizing SNP chips in animal breeding:

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Published 24.01.2024

1. High-Density Genomic Information:

SNP chips provide high-density genotyping, allowing the simultaneous analysis of thousands to millions of SNPs across an individual's genome. This extensive genomic information offers a comprehensive view of the genetic makeup.

2. Genomic Selection Accuracy:

Genomic selection is facilitated by SNP chips, enables the accurate prediction of an animal's genetic merit for various traits. This helps breeders make informed decisions about which animals to select for breeding and thereby contributing to success of breeding programs.

3. Accelerated Genetic Progress:

The use of SNP chips accelerates genetic progress by allowing breeders to identify and select animals with desirable traits at an early age. This rapid genetic improvement contributes to increased productivity and efficiency in animal production.

4. Marker-Assisted Selection (MAS):

SNP chips support marker-assisted selection, where specific genetic markers associated with desired traits are identified. This targeted approach allows breeders to make precise selections, enhancing the efficiency of breeding programs.

5. Optimized Breeding Objectives:

Breeders can customize their breeding objectives by selecting specific SNPs associated with traits relevant to their production goals. This targeted approach allows for the development of animals with traits that are economically and environmentally beneficial.

Disadvantages

While SNP chips have revolutionized cattle breeding by providing valuable genomic information, there are some drawbacks and challenges associated with their use.

1. Limited Functional Information:

SNP chips primarily provide information about genetic variations but do not necessarily offer functional insights into how these variations affect specific traits. Understanding the functional consequences of genetic markers is crucial for targeted breeding.

2. Incomplete Coverage of the Genome:

While SNP chips provide high-density genotyping, they may not cover the entire genome comprehensively. Some regions, including non-coding regions and structural variations, may be poorly represented, limiting the ability to capture all genetic variation.

4. Ascertainment Bias:

SNP chips may not be equally informative across different cattle breeds or populations. Markers identified in one population may not be as relevant or applicable to

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Published 24.01.2024

others, leading to creation of ascertainment bias.

5. Economic considerations:

While the cost of genotyping has decreased over time, SNP chips can still be relatively expensive, especially for large-scale breeding programs. This may limit the accessibility of genomic technologies for smaller-scale or resource-constrained operations.

6. Limited Information on Rare Variants:

SNP chips are designed to capture common genetic variations, and they may not provide detailed information about rare variants that could be important for specific traits or diseases.

7. Interpretation Challenges:

Interpreting the genomic data generated by SNP chips requires expertise in bioinformatics and statistical analysis. Breeders may face challenges in accurately interpreting and translating genomic information into actionable breeding decisions.

Conclusion

SNP chip has emerged as a valuable tool in cattle breeding. It has helped in implementation of productive and reproductive traits at genome wide scale. The targeted approach of selection through SNP chips has fastened genetic progress. Despite drawbacks of economic cost, lesser detection of rarer alleles and ascertainment bias created due to development of SNP chips in different breed. SNP chips continue to be one of the most important pillars for cattle breeding across the world. It is now being supplemented through various genomics and phenomics data to increase accuracy of selection and improve precision breeding.

References

Dash, S., Singh, A., Bhatia, A. K., Jayakumar, S., Sharma, A., Singh, S., Ganguly, I., & Dixit, S. P. (2018). Evaluation of Bovine High-Density SNP Genotyping Array in Indigenous Dairy Cattle Breeds. *Animal biotechnology*, *29*(2), 129–135.

Blasco, A., & Toro, M. A. (2014). A short critical history of the application of genomics to animal breeding. *Livestock Science*, *166*, 4-9.

Ahmad, S. M., De Donato, M., Bhat, B. A., Diallo, A. B., & Peters, S. O. (2023). Editorial: Omics technologies in livestock improvement: From selection to breeding decisions. *Frontiers in genetics*, *13*, 1113417. https://doi.org/10.3389/fgene.2022.1113417